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ABSTRACT

This study investigated the use readers make of visual and verbal illustration to understand and remember what they have read. Specific focus was placed on readers' use of pictures and analogies to understand and remember written directions for a spatial manipulation task. The independent variables measured were type of text, mode of illustration, and time of recall. Results indicated that readers have a better understanding of written directions for a spatial manipulation task when pictorial information is supplied. When procedural instructions include both pictorial and textual support, readers use pictures to greater effect. The purposes of directions should be considered. If immediate comprehension is the only desired outcome, literal directions supplemented by pictures should facilitate efficient performance. However, if the aim is to promote long term retention, then devising an analogy as a mnemonic device would be productive. (DWH)

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Relative Effects of Analogies and Pictures On Understanding and Remembering Written Directions

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Running Head: Analogies and Pictures

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Relative Effects of Analogies and Pictures on Understanding and Remembering Written Directions

The purpose of this study was to investigate the use that readers make of visual and verbal illustration to understand and remember what they read. Its focus was on readers' use of pictures and analogies to understand and remember written directions, or procedural texts, as they are called in the educational technology literature.

The explanatory and heuristic functions of pictures and illustrative language have been discussed widely, yet few studies have systematically examined the way readers use them for understanding and remembering procedural tasks. Stone and Glock (1981) reported a study in which readers made significantly fewer uncorrected errors on a procedural assembly task completed with the aid of pictures. In prose-learning experiments by Mayer (1975), Royer and Cable (1976), and Rigney and Lutz (1976) pictures and analogies have been shown to be helpful for learning technical information from texts, but none of these experiments differentiated readers' use of pictures and analogies.

Hayes and Henk (1983) reported a study that attempted to compare the relative value of analogies and pictures for readers' understanding a knot-tying procedure and their remembering it ten days later. They found that for an immediate understanding of the procedures, subjects who were given pictures to accompany the written directions performed significantly better than subjects whose directions contained no pictures. Whether the pictures were functional line drawings or expressive cartoons made no

difference. Nor did it make any difference whether subjects read instructions that described the procedure in literal terms or illustrated with an analogy to a fictitious circumstance. After the 10-day retention interval the analogy to the fictional circumstance did appear to make a difference. Eight out of 12 subjects who had initially read and understood the analogic instructions could still tie the knot without any directions available, whereas only three of the 12 subjects who had initially read and successfully used the literal instructions could remember how to tie the knot. However, two problems with that study stood in the way of interpreting its results unambiguously. First, because there was no condition that had subjects use directions containing only pictures — that is, without written directions — it was not possible to unambiguously assess the relative value that pictures and written directions hold for readers. Second, because the memory phase of the study — after the 10-day retention interval — included only individuals who had successfully tied the knot on the first sitting, it is possible that the superior performance of subjects who had initially read the analogic instructions could be due to superior learning ability; it is possible that quite different results would have been observed had all of the subjects been included in the second phase of the study as well.

Method

Subjects and Design

The present study was designed to address the problems of our earlier study. Again using high school subjects, the study was conducted in two phases separated by an interval of two weeks. One hundred two subjects

were assigned at random to one of six treatment groups representing all combinations of the two between-subjects factors: analogic-versus-literal text, and no-pictures versus pictures-only versus pictures-plus-text. Again we asked subjects to tie the knot after a delayed time. Thus time of performance was designated as a within-subjects factor. The study was a (^{2}type of text X ^{3}modes of illustration X ^{2}times of performance) mixed design.

Materials

Both the literal and analogic instructions explained how to tie the bowline knot in five steps. The analogic instructions contained directions to imagine an analogous fictional circumstance of a rabbit guarding his territory. The elements of the analogous fiction corresponded to the steps of tying the bowline knot. Two sets of five expressive drawings were created to illustrate the five steps of tying the knot. One set corresponded to the literal instructions. It indicated the placement of the rope and the placement of the hands performing the task. The other set of drawings corresponded to the analogic instructions. It depicted the five steps of tying the bowline by cartoon-like representations of a rabbit appearing at the lower end of the rope and a tree appearing at the upper end of the rope.

Procedure

Students were observed individually by three raters on occasions two weeks apart. Understanding written directions was operationally defined as the degree of accuracy subjects demonstrated in tying the bowline knot. Accuracy was gauged by tallying the number of correct manipulations

with the rope. One point was given for each correct manipulation. Startovers were allowed, but no credit was given for previously accomplished steps on successive trials. Because the procedure was serial in nature, no credit was given for performing steps out of order. At the second sitting two weeks later we asked the students to recall their first encounter with the instructional materials and the knot-tying procedure. We allowed the students two minutes to tie the knot and then we again asked the subjects to tell us what they remembered about how the instructional materials had described the procedure two weeks earlier.

Results

For the purposes of this study, understanding written directions (immediate learning) was operationally defined as the degree of accuracy subjects demonstrated in tying a bowline knot. Accuracy was gauged by tallying the number of correct rope manipulations made by each subject. One point was awarded for manually performing each of the five specific steps necessary to tie the knot. Subjects' scores ranged from a minimum of zero for no steps completed to a maximum of five points for a fully-formed bowline. While startovers were allowed, no credit was given for repeating previously-accomplished steps on successive trials. Because the knot-tying procedure was serial in nature, no credit was given for performing steps out of order either. Durability of learning (delayed recall) was operationally defined as the degree of accuracy subjects demonstrated in tying the bowline knot from memory after a retention interval of two weeks. The same method of determining accuracy in Phase I, i.e., tallying the number of completed steps, was again used in Phase II.

Means and standard deviations for all 12 treatment conditions are presented in Table 1. An examination of this table reveals that the mean scores ranged from a minimum of 1.00 for the Literal/Text Only/Delayed condition to a maximum of 4.29 for the Literal/Text plus Pictures/Immediate treatment. The highest mean score generated among all delayed recall conditions occurred for the Analogic/Text plus Pictures treatment. In all instances, the means of the text-picture formats were higher for the immediate learning phases than they were for the equivalent delayed recall conditions. Across the two types of text conditions, the means of the Pictures Only treatments were nearly identical within the immediate learning phase and also within the delayed recall phase.

Insert Table 1 About Here

To determine the effects of the three independent variables (type of text, mode of illustration, and time of recall), the data were subjected to a 2 X 3 X 2 mixed analysis of variance procedure. In this statistical model, type of text and mode of illustration represented between-subjects factors, while time of recall served as a within-subjects factor. Results of this three factor analysis indicated a significant main effect for mode of illustration, $F(2,96)=16.76$, $p < .0001$. Post hoc analyses using the Newman-Keuls Multiple-Comparison Test revealed that the Text Only mean (1.84) differed significantly ($p<.01$) from the means of both the Pictures Only (3.07) and Text plus Pictures (3.16) groups but that these two latter means were not significantly different from each other ($p<.18$). The main

analysis also indicated significance for the Time of Recall main effect, $F(1,96)=84.123$, $p<.0001$. An inspection of the two means indicated that performance was greater for the immediate learning phase (3.33) than it was for the delayed recall phase (2.05). Because the instructional materials were made available to subjects in the immediate learning phase but not in the delayed recall phase, this trend was anticipated.

Significant first-order interactions occurred for Type of Text X Time of Recall $F(1,96)=5.28$, $p<.02$, and for Mode of Illustration X Time of Recall, $F(2.96)=6.01$, $p<.003$. For the text by time interaction, the Newman-Keuls Test revealed that each of the means differed significantly from one another ($p<.01$) except for the comparison between the Literal Text/ Immediate Learning (3.31) and Analogic Text/Immediate Learning (3.35) conditions. This interaction is depicted in Figure 1. The Figure demonstrates that the analogic text conditions outperformed the literal conditions in the delayed recall phase of the experiment.

Insert Figure 1 About Here

The results of the post hoc analyses for the Mode of Illustration by Time of Recall interaction appear in Table 2. This table shows that the Text Only/Delayed Condition mean differed significantly from all others. The table also indicates that when immediate learning was assessed the Pictures Only and Text plus Pictures conditions did not differ ($p<.05$).

Insert Table 2 About Here

A visual representation of this interaction effect is presented in Figure 2. This diagram suggests that performance declined markedly for both the

Text plus Pictures conditions and Pictures Only conditions in the delayed recall phase. The discrepancy between immediate and delayed performance was less dramatic for the Text Only groups although the difference was still significant at the .05 level.

Insert Figure 2 About Here

Discussion

The results of the experiment support in large measure our earlier findings. Both studies indicate that readers better understand written directions of a spatial manipulation task when pictorial information is supplied. Type of pictures makes little difference in performance when the necessary spatial and operational information is available to the reader. In fact, all of the illustrated conditions in both studies resulted in significantly better performance than their unillustrated counterpart conditions. That the scores were comparable for the pictures-only condition and the text-plus-pictures conditions strongly suggests that a large portion of the total variance generated by the text-plus-pictures condition was explained by pictures. The clear noncomparability of the text-only condition with either of the other conditions further supports this conclusion. From the data it seems reasonable to infer that when procedural instructions include both pictorial and textual support, readers use pictures to greater effect. (This would of course depend on the nature of the task to be performed: knot-tying is a highly visual task whose facilitation is apparently best accomplished by providing pictures of the process.)

Although time of performance is of somewhat limited value when viewed as a main effect, its inclusion in the design provided some revealing interactions. Performance in the text-only conditions declined less sharply over time than in the treatment conditions that included pictures, surely because the subjects in the text-only conditions had acquired less knowledge initially — and had less to forget. The much larger disparity between the initial and delayed performance of the text-plus-pictures subjects may be attributable to an over-reliance on the pictures initially. Since the subjects did not know that they would be asked to perform the task again at a later date, they probably made little effort to integrate the textual and pictorial information in such a way that would be useful for remembering it. This conclusion is supported in part by the finding that subjects in the pictures-only conditions performed nearly as well as those in the text-plus-pictures groups. Both were probably relying on the information they had attended to most closely in the initial learning phase — that provided by the pictures.

In initial learning we observed nearly equivalent results for the literal and analogic instructions. However, when we assessed durability of learning in the delayed recall task, subjects in the analogic condition significantly outperformed students in the literal conditions. Perhaps analogy does not facilitate immediate learning because the reader must attempt to process the literal aspects of the task along with the analogy itself. In this instance, there may develop a competition for attention between the literal steps, their analogous counterparts, and the actual manipulation of the rope. The processing burden may inhibit task performance.

Because in our previous study we examined durability of learning only with subjects who had reached criterion in initial learning, we may have

inadvertently identified a subgroup of exceptional learners to test the power of analogy. It was possible that the analogy was facilitating only for superior students who had used it to good advantage in the first place. The present study dealt with this problem by including all subjects in the retention phase. Consequently, the analysis was sensitive to recall operations among individuals who scored at various levels on the immediate learning task. The results show that the value of analogy for remembering a procedural task is not limited to superior learners.

Some interesting qualitative data were obtained by observing the strategies of successful subjects in the text-plus-pictures conditions at the first sitting and two weeks later questioning those who could still tie the knot how they remembered to do it. On the whole, subjects who were initially successful tended to employ the same strategy: First, they silently read the text in its entirety. Next they reread the text to the point where the first step was fully described. Regardless whether they understood the directive, they nearly always checked the accompanying picture for verification. If they were satisfied by their visual inquiry, they tried that step. If not, they tended to recite the directive to themselves in subvocal fashion until they felt they understood it well enough to refer back to the picture. From this point on, they attempted the step, referring to the picture almost exclusively for assistance. Then they returned to the text, read the extent of the next directive, and followed essentially the same pattern used to complete the previous step. When they completed the knot, they again inspected the pictures in sequence from first to last as a final check of their work.

In the post-experimental interview of subjects in the text-plus-pictures groups who had remembered how to tie the knot said that <u>remembering the</u>

pictures was most useful as an aid to memory. Many reported having only a vague recollection of the text content and had previously relied on the pictures as the definitive source of correct information. Interestingly, subjects in the analogic text-plus-pictures group made far fewer references to the pictures as facilitating retention. Instead, these individuals attributed their recollection to the verbal analogy. When we asked subjects who had reached criterion in both of the text-plus-pictures groups why they had initially checked the text against the pictures and vice versa, they said that they had learned from experience that it was effective practice but that they had never been formally taught to use such a strategy.

One unexpected outcome of the post-experimental interviews was that most of the subjects in the pictures-only condition indicated that in the absence of verbal directions, they tended to invent their own. They reported examining the pictures, then transforming their perceptions into a series of verbal propositions: "First I've got to make a small loop, then I've got to bring the bottom end of the rope up through the loop...."

Conclusions

The results of the study support these conclusions: First, when procedural instructions were developed, supplying pictures to illustrate the steps of the procedure seems advisable. In no instance did pictures inhibit performance. The primary requirement would be that they portray the necessary spatial and operational information.

Second, the purposes of the directions should be considered. If immediate comprehension is the only desired outcome, then literal directions

supplemented by pictures should facilitate performance as efficiently as any other condition examined in this study. If, on the other hand, the aim is to promote long-term retention of the steps, then devising an analogy as a mnemonic device seems productive.

Finally, since one basic strategy was used consistently by subjects reaching criterion in the text-plus-pictures treatments, students might be encouraged to adopt this strategy as a means of approaching procedural tasks.

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Table 1

Means and Standard Deviations for Knot-Tying Manipulations Achieved

TYPE OF TEXT	ILLUSTRATION MODE	TIME OF RECALL: Phase I (Immediate Learning) $\bar{X}$	SD	(*)	Phase II (Delayed Recall) $\bar{X}$	SD	(*)
Literal	Text Only	1.76	1.437	(1)	1.00	.935	(0)
	Pix Only	3.88	1.219	(8)	2.29	1.160	(2)
	Text + Pix	4.29	.985	(10)	1.76	.831	(0)
Analogic	Text Only	2.47	1.328	(3)	2.12	1.317	(2)
	Pix Only	3.82	1.185	(6)	2.29	1.611	(3)
	Text + Pic	3.76	1.522	(9)	2.82	1.704	(3)

N = 17

* Parentheses indicate the number of subjects reaching criterion.

Table 2

Post Hoc Analyses for the Illustration X Time Interaction

CONDITION	Text Only Delayed	Text Only Immediate	Pix Only Delayed	Text + Pix Delayed	Pix Only Immediate	Text + Pix Immediate
MEAN	1.56	2.12	2.29	2.30	3.85	4.03

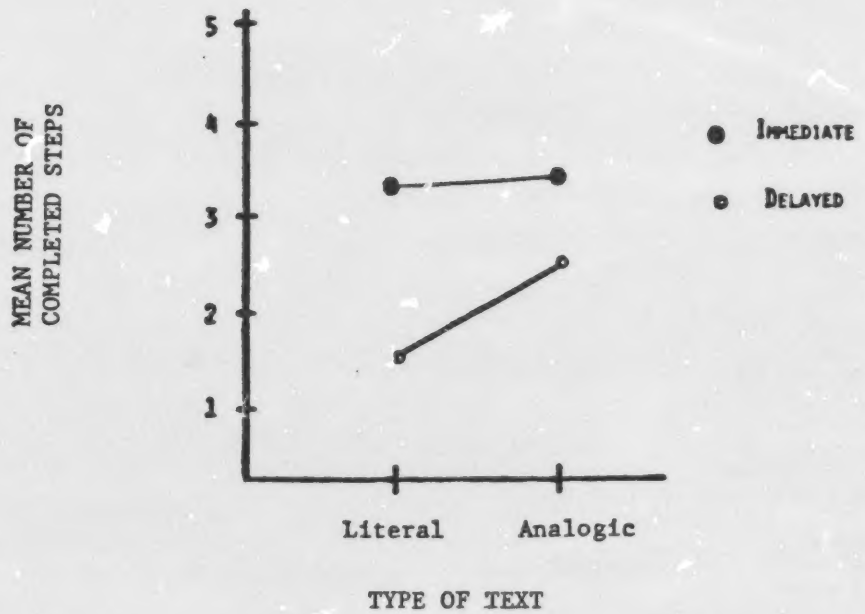

Figure 1. Interaction Between Type of Text and Time of Procedure

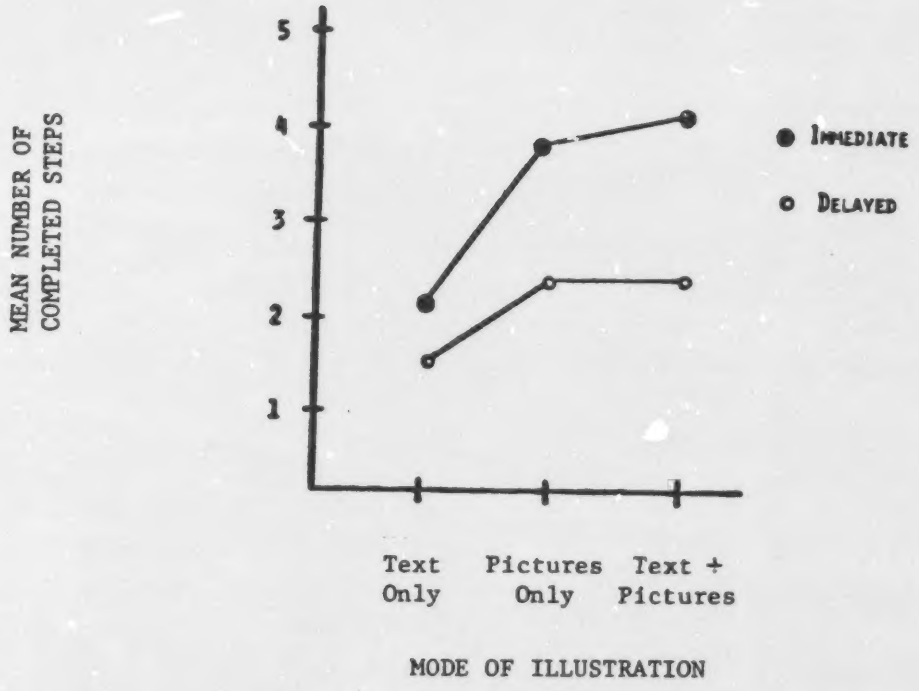

Figure 2. Interaction Between Picture Condition and Time of Procedure